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Original Communication

The value of subendocardial haemorrhages as an indicator of exsanguination and brain injury – A retrospective forensic autopsy study

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Abstract

Introduction: Subendocardial haemorrhages (SE) have been associated with multiple causes of violent and non violent deaths in forensic autopsies such as fatal exsanguination, brain injury and intoxications.
Methods: The presented retrospective study investigates the overall incidence and various causes by an analysis of a total of 1331 forensic autopsies based on autopsy reports.
Results: The results show that head injury and significant blood loss alone or in combination are the main causes of death associated with SE. The incidences of SE were 50% in exsanguination, 80% in combined exsanguination and head injury, and 31% in solitary head trauma.
Discussion: On the basis of the study results it can be concluded, that SE are important indicative signs for both fatal exsanguination and brain injury at medico-legal autopsies.

Keywords: Subendocardial haemorrhage; Exsanguination; Brain trauma

1. Introduction

In textbooks of forensic medicine and several studies of medico-legal autopsy cases subendocardial haemorrhages (SE), defined as macroscopically visible bleedings at the inner surface of the septal part of the left ventricle (Fig. 1), have been associated with several forms of traumatic death such as death by exsanguination, brain injury, incineration, hyperthermia, electrocution or intoxications by various agents such as intravenous drugs (i.e. opiates, cocaine) and arsenic.[1–11] According to early studies by Meixner,[1] the incidence of SE in cases of death by blood loss would be 60%. A more recent retrospective autopsy study by Harruf,[7] showed the strongest correlation to fatal brain injuries (60% incidence), followed by intoxications (14%) and abdominal injuries (12%).

Histological studies have shown that the term subendocardial haemorrhage may be misleading. It has been proven, that in most cases, no haemorrhages but only a subendocardial hyperaemia can be demonstrated histologically.[8] On the other hand, they may hide more than just mere haemorrhages since minute necrosis of myofibers in the subendocardium and other parts of the heart muscle have been found in cases with SE, where the survival time is longer than six hours.[9] The pathophysiological pathways that produce these lesions are not completely understood. At first it was thought that they might be a consequence of rupture of congested subendocardial blood vessels in heart failure or due to vigorous contractions of empty ventricle walls without the cushioning effect of blood in

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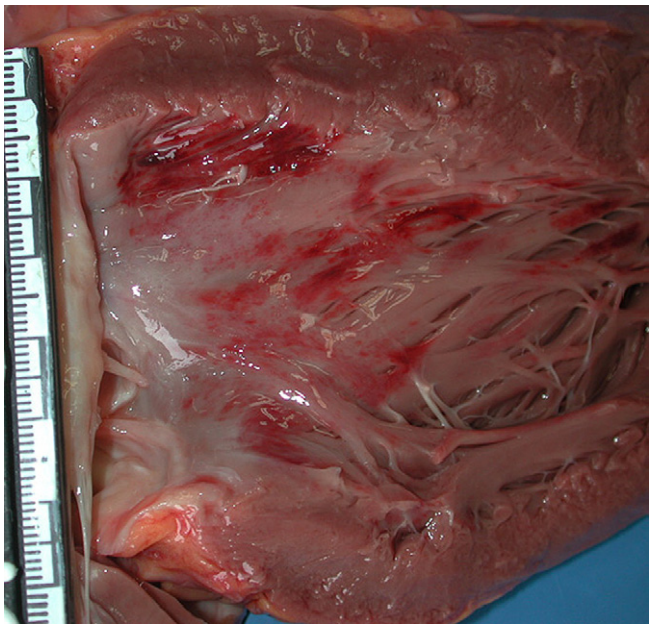

Fig. 1. Example of typical subendocardial hemorrhages beneath left ventricular wall in a case of fatal exsanguination.

hypovolemic shock.[4,6] More recent studies suggest, that high levels of catecholamines might cause secondary heart damage resulting in fatal arrythmias.[6,7] As a consequence, any major traumatic event that provokes high levels of stress induced hormones could produce SE and trigger death by heart failure.[7,9]

Based on the literature the forensic relevance of SE would therefore lie in the fact that they may represent a possible mechanism of death by itself and might point to a non-cardiac traumatic event in cases with no obvious injuries and to conditions that easily escape the naked eye at forensic autopsy such as fatal intoxications,[4,7,10] hyperthermia[4] or electrocution.[5]

In fatal blood loss SE may have great importance as possible key findings and vital signs. The post-mortem diagnosis of death by exsanguination is often difficult at forensic autopsy. The amount of external blood loss can only rarely be measured, and the signs indicating vital exsanguination such as a small amount of livor mortis or bloodless inner organs can be unspecific or false positive due to a pre-existent anaemia or post-mortem blood loss. It has been experimentally proven that a considerable blood loss resulting in a marked reduction of livores can be produced after death[12,13] – an artefact that can be observed after every autopsy.

In this context, it was the goal of the following retrospective study to investigate the incidence of SE, their relationship to the causes of death with the focus on their diagnostic value and as a vital sign.

2. Methods

In this retrospective study all autopsy cases performed or supervised by a board certified forensic pathologist at the Institute of Forensic Medicine, Berne, Switzerland between the 1.1.2003 and the 31.12.2006 were analyzed on the basis of autopsy protocols regarding the presence of SE. The results were used to calculate the total incidence of SE and relate them to the cause(s) of death. All cases with SE were further analyzed for the mechanism and manner of death, as well as for major traumatic findings to the chest (i.e., soft tissue injuries to the thorax, rib or sternum fractures and lung injuries by either blunt or penetrating trauma or due to resuscitation attempts), with the latter being excluded from the study in order to prevent bias from a direct traumatic genesis of SE.

To investigate the incidence of SE in fatal blood loss and brain trauma, all cases with the diagnosis of substantial internal and/or external haemorrhage and/or head injury that had been judged as the mechanism of death alone or in combination with other injuries were analyzed for the presence of SE. The diagnosis of relevant blood loss was established in cases, where a blood accumulation of at least 1000 ml in internal cavities (i.e. pleural or peritoneal) or – in cases of external blood loss – indirect signs such as scarce amount of livor mortis and bloodless inner organs were documented in the autopsy protocol.

3. Results

From a total of 1331 included autopsies, SE were documented in 119 cases (9% of all autopsy cases). Among the cases with SE the interval of time between the injury and death was less than 24 h in 116 cases (97% of all SE-cases), between 24 and 48 h in three cases, between 48 and 72 h in two cases and unknown in one case. The mean age of the deceased with SE was 39 years. The youngest victim was

Table 1
Manner of death and their incidence in cases with subendocardial hemorrhage

Manner of death in cases with SE	No.	%
Accidents:	64	54
Traffic accidents (45)		
Accidental falls (9)		
Train accidents (5)		
Plane crashes (5)		
Homicides:	22	18.5
Gunshot injuries (12)		
Penetrating injuries (6)		
Blunt injuries (4)		
Suicides:	17	14
Gunshots (6)		
Falls from height (4)		
Penetrating injuries (2)		
Running over by train (2)		
Hanging (1)		
Miscellaneous (2)		
Natural:	13	11
Spontaneous internal hemorrhage (11)		
Coronary deaths (2)		
Medical malpractice:	3	
Total	119	

Table 2
Mechanisms of death and their incidences in cases with subendocardial hemorrhage (SE)

Mechanisms of death in cases with SE	No.	%
Blood loss and head injury combined	25	21
Blood loss and thoracic trauma combined	22	18
Blood loss	21	18
Blood loss, head injury and thoracic trauma combined	19	16
Body disintegration	18	15
Head injury	9	8
Miscellaneous	5	4
Coronary disease (2)		
Hypoglycemia (insulin overdose, 1)		
Heat stroke (1)		
Suffocation (hanging, 1)		
Total	119	

six, the oldest 68 years. 25% of all victims were females, and 75% were males.

Among the 119 SE-cases 64 (54% of all SE-cases) were accidents, 22 (18.5 %) cases were homicides, 17 cases (14%) were suicides, 13 (11%) cases were natural deaths and 3 (3%) cases were fatalities due to medical malpractice (Table 1).

In half of all cases with SE (49%), substantial thoracic trauma was documented among other injuries. There was no case with isolated chest trauma in all of the cases with SE.

Signs of a substantial loss of blood (external or internal) were found in 18% of all cases with SE. Solitary brain trauma was found in 8%, a combination of major blood loss with brain trauma in 21% and miscellaneous mechanisms of death in 4% of all SE-cases (Table 2).

Among the total of 1331 autopsy cases during the study time, there were 224 cases of fatal intoxication and 13 heat related deaths. There was no case of fatal intoxication among the SE-cases and only one case with the diagnosis of hyperthermia. Among the 119 cases with SE toxicological analysis (blood alcohol determination and screening for illegal drugs and prescription medicaments) were performed in all traffic accident cases, accidental falls, plane crashes as well as in every homicide case (81 cases). No relevant toxicological findings regarding the cause of death were found in these cases.

Of all 1331 forensic autopsies performed in the investigated four years period of time, the diagnosis of fatal blood loss was established in a total of 221 bodies, and the diagnosis of significant brain trauma in 140 cases. In 259 of these added 361 cases additional significant thoracic trauma was documented. These were excluded from further analysis. Of the remaining 102 bodies, 42 had suffered major blood loss, 31 presented with a combination of major blood loss and significant brain trauma, and in 29 cases a solitary significant brain trauma was documented. In 21 of the 42 cases with fatal blood loss as the solitary cause of death SE were found. This accounts for an incidence of 50% in the exsanguination cases. The incidence of SE in the cases with solitary and fatal brain trauma was 31% (9 out of 29 cases). The highest incidence of 80% (25 out of 31 cases) was found when a combination of relevant blood loss and significant brain trauma had been present.

4. Discussion

Based on the study results we conclude, that, with an overall incidence of 9% in the examined autopsies, SE are frequent findings in forensic autopsies. After the exclusion of a direct traumatisation of the heart as a possible causative factor, half of all examined cases with exsanguination as a solitary cause of death and one third of all deaths due to an isolated brain injury showed SE. The highest incidence (80%) was observed in cases where significant blood loss and brain injuries were combined. It can therefore be concluded, that SE are important indicative signs for both fatal exsanguination and brain injury at medico-legal autopsies and emphasize their value as an important vital sign in post-mortem diagnosis of fatal blood loss.

Regarding the incidence of SE in exsanguination, our results confirm the observations made by Meixner in the 1940s. On the other hand, at a first glance, they seem to contradict those by Harruff since in his study, fatal haemorrhage is not mentioned as a separate cause of death associated with SE. A closer look at Haruff's data, however, suggests that a major blood loss may have played a role as a concomitant cause of death in combination with craniocerebral trauma and abdominal injuries (i.e. gunshot wounds and stab wounds) in some cases.

Among the 119 cases with SE toxicological examinations were performed in 81 cases (traffic accident cases, accidental falls, plane crashes as well as in the homicide cases). No relevant levels of illegal drugs and prescription medicaments regarding the mechanism of death were detected in these cases. On the other hand we found no case with SE among 224 cases of fatal intoxication by illegal substances and prescription medications that were examined in the investigated period of time. Further prospective studies would be needed to investigate this question, but our results suggest, that – contrary to previously published data[9] – SE may play a minor role as an indicative sign in fatal intoxication by intravenous drugs and prescription medication in medico-legal practise.

Regarding the other causes of death that are associated with SE in forensic textbooks such as heat stroke and electrocution we can draw no further conclusion on the incidence due to insufficient case numbers during the investigated period of time.

It must be pointed out, that morphological studies were not the scope of this investigation. Tissue samples and microscopic slides are not available in the study cases since histological analyses of SE were not performed regularly as a matter of routine in our institute up to this date. The diagnosis of SE was solely based on the macroscopic observation by the forensic pathologist performing the autopsy. Furthermore, there are no possibilities to objectively rate

and specify the extent of the haemorrhages on the basis of the autopsy protocols. More prospective studies would be needed to investigate macroscopic and histological form and appearance, extent and dimensions in relation to the possible causative factors involved.

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